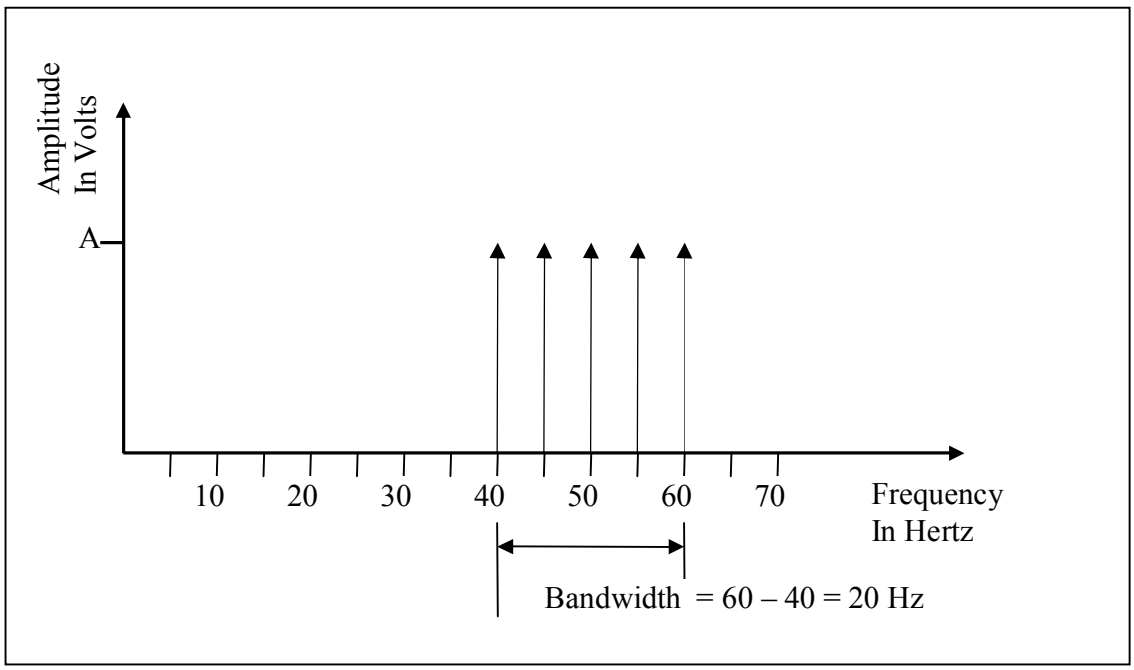
Data communications and Encoding

1. A signal has a bandwidth of 20 Hz. The highest frequency is 60 Hz. What is the lowest frequency? The signals frequency content is analysed to a resolution of 5Hz. Every component is found to have the same amplitude of A volts. Draw the spectrum of the signal.

   $B = f_h - f_l$
   $20 = 60 - f_l$
   $f_l = 60 - 20 = 40$ Hz



2. A signal has a spectrum with frequencies between 1000 and 2000 Hz (bandwidth of 1000 Hz). A medium can pass frequencies from 3000 to 4000 Hz (a bandwidth of 1000 Hz). Can this signal faithfully pass through this medium?

   The answer is definitely no. Although the signal and the medium can have the same bandwidth (1000 Hz), the range does not overlap. The medium can only pass the frequencies between 3000 and 4000 Hz so the signals frequencies of 1000Hz to 2000Hz are totally lost.

   The medium described in the question is essentially a bandpass filter. You can think of a bandpass filter as being a paling fence with gap in it. Only something that is lined up with the gap can get through the fence. You can also have high-pass and low-pass filter.

   All media have a frequency response. Communications signals have to be tailored to takes these into account if the best performance is to be achieved.

3. In a Communication Channel, it was found that the Signal-to-Noise Ratio is 27 dB. Assume that the communication line has the bandwidth of 3 kHz, calculate the Channel Capacity for this connection.

Also, find the number of levels required for the Channel Capacity.

To use Shannons Law, the SNR value has to be linear (no units). We are given the SNR in dB so first we have to convert.

SNR (ratio) = $10^{27/10}$
= 501.18

Now using Shannon's Law:

$C = B\log_2 (1 + SNR)$
$= 3000 * \log_2 (1 + 501.18)$
$= 3000 * [\log_{10}(502.18)/\log_{10} 2]$
$C = 26.92$ kbps

Note :
the use of the change-of-base formula;

$$\log_X(Y) = \log_{10}(Y) / \log_{10}(X)$$

This should be highlighted to students

To find the number of levels needed, using Nyquist's Theorem:

$C = 2B\log_2(M)$
$B\log_2(M) = C/2$
$\log_2(M) = C / (2 * B)$

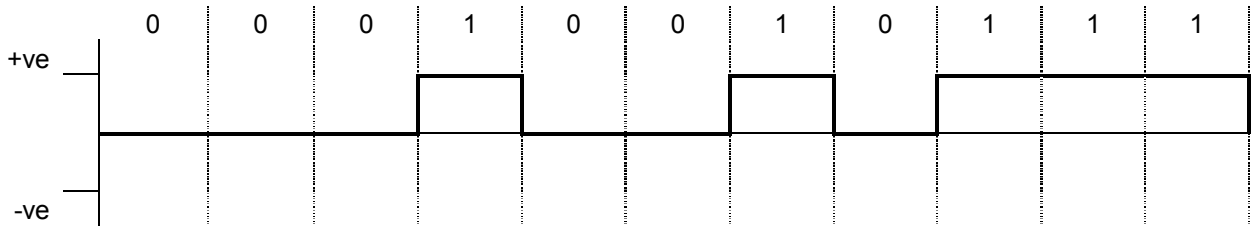
$\log_2 (M) = 26.92 * 10^3/(2 * 3000)$
$\log_2 (M) = 4.48$
$M = 2^{4.48}$
$M = 22.32$

But you cannot have a part-level, so round up;

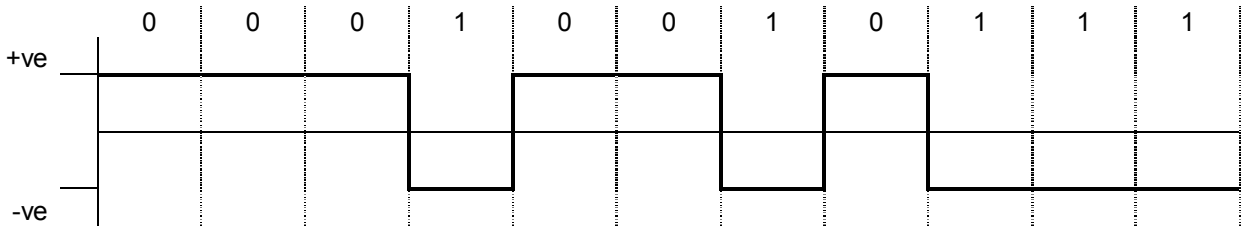
M = 23 levels

4. Assume a data stream is made of the following bit sequence 0 0 0 1 0 0 1 0 1 1 1. Encode this stream, using the following encoding schemes.
    a) Unipolar
    b) NRZ-L
    c) NRZ-I
    d) Manchester
    e) Differential Manchester

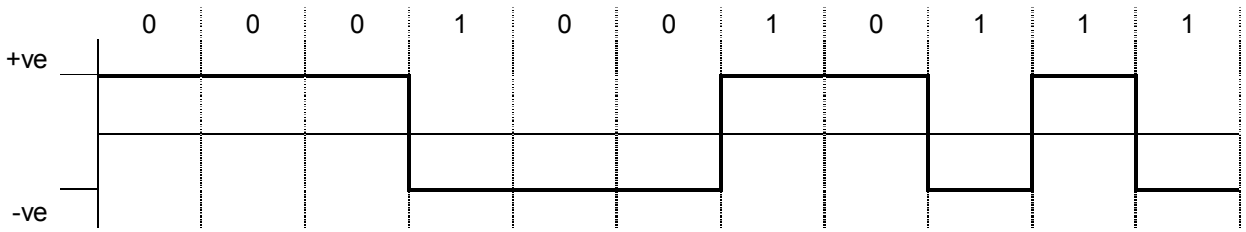
f) Unipolar (send ; 0 Volts for a 0 and +ve Volts for a 1)



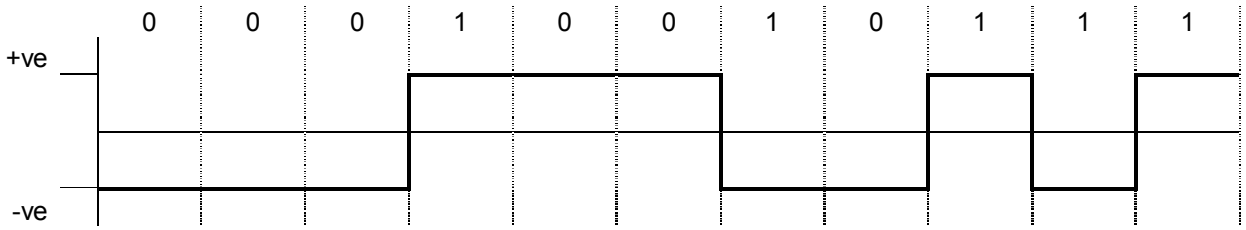
g) NRZ-L (send; +ve Volts for a 0 and –ve Volts for a 1)



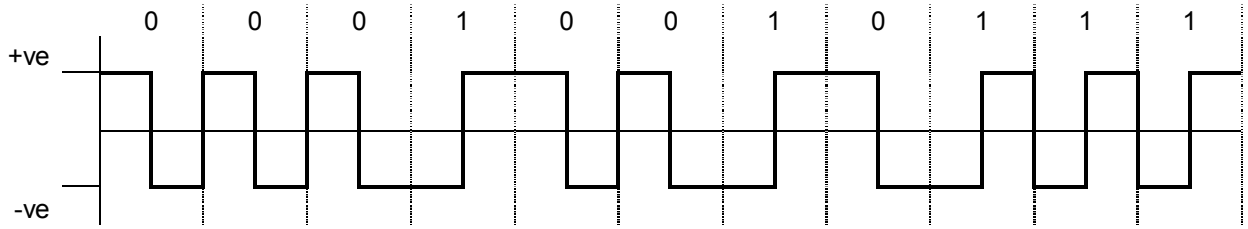
h) NRZ-I (the signal changes polarity at each 1 in the data stream)



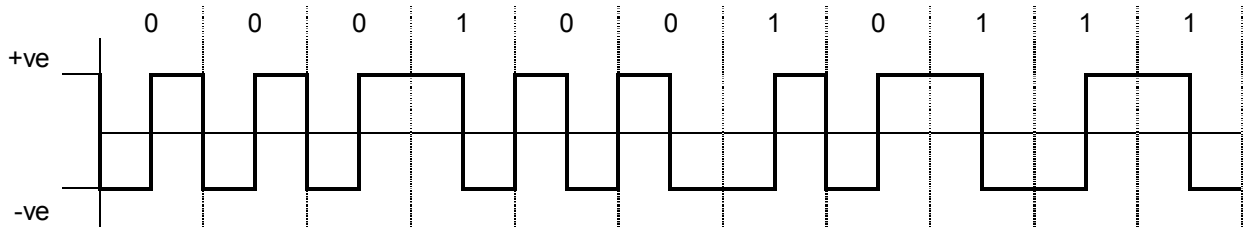
OR (there are two possible answers because it depends on what the previous bit was)



i) Manchester



j) Differential Manchester



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